METHODS AND APPARATUS TO DEFINE STAGES FOR MULTI-VARIATE BATCH CONTROL ANALYTICS

FIELD OF THE DISCLOSURE

[0001] This disclosure relates generally to process control systems and, more particularly, to methods and apparatus to define stages for multi-variate batch control analytics.

BACKGROUND

[0002] Some process control systems are implemented using batch process control. During the execution of a batch process, operators and/or other plant personnel may implement analytical models that are applied to the current batch process to ensure the batch process proceeds as expected. The models can be generated based on data collected from previously executed batch processes. The effectiveness of the analytical models depends upon the reliability of the data used in generating the models and the accuracy of the models in representing actual processing conditions of the current batch process to which the models are being applied.

SUMMARY

[0003] Example methods and apparatus to define stages for multi-variate batch control analytics are disclosed. An example method includes determining, with the processor, a current stage in a current batch process based on a current value of a batch stage parameter. The current value of the batch stage parameter determined based on process control data associated with process parameters in the current batch. The current stage determined independent of batch events defined by at least one of a start or an end of procedures, unit procedures, operations, or phases in a batch recipe. The example method further includes applying, with the processor, a model to the current batch process, the model corresponding to the current stage.

[0004] An example apparatus includes a batch stage analyzer, implemented via a processor, to determine a current stage in a current batch process based on a current value of a batch stage parameter. The current value of the batch stage parameter determined based on process control data associated with process parameters in the current batch. The current stage is determined independent of batch events defined by at least one of a start or an end of procedures, unit procedures, operations, or phases in a batch recipe. The example apparatus also includes a batch model analyzer to apply a model to the current batch process, the model corresponding to the current stage.

[0005] An example article of manufacture includes instructions that, when executed, cause a machine to at least determine a current stage in a current batch process based on a current value of a batch stage parameter. The current value of the batch stage parameter determined based on process control data associated with process parameters in the current batch. The current stage is determined independent of batch events defined by at least one of a start or an end of procedures, unit procedures, operations, or phases in a batch recipe. The instructions further cause the machine to apply a model to the current batch process, the model corresponding to the current stage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1** is a Gantt-type chart representative of the procedural elements in an example batch recipe.

[0007] FIG. **2** is a schematic illustration of an example process control system.

[0008] FIG. **3** illustrates an example manner of implementing the example batch execution engine of FIG. **2**.

[0009] FIGS. **4-7** are flowcharts representative of example methods that may be carried out to implement the example batch execution engine of FIGS. **2** and/or **3**.

[0010] FIG. **8** is a schematic illustration of an example processor platform that may be used and/or programmed to carry out the example methods of FIG. **4-7**, and/or, more generally, to implement the example batch execution engine of FIGS. **2** and/or **3**.

DETAILED DESCRIPTION

[0011] A standardized procedural control model or framework for batch control was adopted by the International Society of Automation (ISA) in 1995 as ISA-88. In particular, the ISA-88 standard defines the procedural control framework for a batch process in the context of a recipe or procedure that may include an ordered sequence of unit procedures, which in turn may include an ordered sequence of operations, which may in turn include an ordered set of phases. A Gantt-type chart representative of the procedural elements in an example batch recipe **100** is shown in FIG. **1**

[0012] As shown in the illustrated example of FIG. **1**, the top layer or highest level element in the recipe **100** is a batch procedure **102** (sometimes called a "recipe procedure" or simply "procedure"). A batch procedure defines the overall strategy to carry out a batch process. The batch procedure **102** of the illustrated example includes two batch unit procedures **104**, **106** (sometimes called a "recipe unit procedure" or simply "unit procedure"). A batch unit procedure defines the strategy to carry out all or a part of a batch procedure within a particular unit in the equipment hierarchy of a process control system. The third level of procedural elements as shown in the illustrated example corresponds to recipe or batch operations. A batch operation defines the strategy to carry out a particular and independent processing activity within a batch unit procedure. As shown in FIG. **1**, the first batch unit procedure **104** includes two batch operations **108**, **110** while the second batch unit procedure **106** includes one batch operation **112**. The lowest procedural elements for batch control are phases, which define the strategy to carry out specific process-oriented tasks or functions associated with the execution of a batch operation. In the illustrated example, the first operation **108** of the first unit procedure **104** includes three phases **114**, **116**, **118**, while the second operation **110** of the first unit procedure **104** includes two phases **120**, **122**. Further, in the illustrated example, the operation **112** of the second unit procedure **106** includes two phases **124**, **126**.

[0013] While most of the different procedural elements in the example recipe **100** of FIG. **1** are represented with generic labels, the phases **114**, **116**, **118** associated with the first operation **108** of the first unit procedure **104** include more particular labels for purposes of explanation. In particular, in the illustrated example, the first phase **114** is a "Material Add Phase" in which materials to be processed are introduced into a tank or other container. The second phase